DOCUMENT RESUME

ED 137 120 SE 022 352

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TITLE An Evaluation of Elementary School Mathematics Programs Utilizing the Mini-Calculator.
INSTITUTION North York Board of Education, Willowdale (Ontario).
SPONS AGENCY Ontario Dept. of Education, Toronto.
PUB DATE Jul 76
NOTE 42p.; For related document, see SE 022 353

EDRS PRICE MF-$0.83 HC-$2.06 Plus Postage.
DESCRIPTORS Academic Achievement; *Educational Research; Elementary Education; *Elementary School Mathematics; Grade 5; Grade 6; Mathematics Education; Questionnaires; Student Attitudes
IDENTIFIERS *Calculators; Research Reports

ABSTRACT

The purpose of this study was to compare the achievement, attitudes, and teaching/learning experiences in mathematics programs of two groups of elementary-school students in grades 5 and 6. Approximately 150 students in each of two elementary schools were given as a pretest a standardized mathematics achievement test and a questionnaire regarding attitudes toward mathematics and the use of calculators in the mathematics program. Then, for a seven-month period, students in one school had calculators available in their classrooms for checking their work, while at the second school no calculators were permitted. At the end of this time, the standardized test and the attitude questionnaire were given as posttests. Results on the achievement test showed that for the computation subtest, there were no significant differences in the gain scores between the two schools. On both the mathematics concepts and the problem-solving subtests, however, fifth graders in the experimental group scored significantly higher than fifth graders in the comparison group. Results on each of the questions on the attitude questionnaire are reported in percentages. An appendix includes a copy of the questionnaire. (DT)

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ED137120

NORTH YORK BOARD OF EDUCATION

RESEARCH REPORT

AN EVALUATION OF ELEMENTARY SCHOOL MATHEMATICS PROGRAMS

UTILIZING THE MINI-CALCULATOR

U S DEPARTMENT OF HEALTH, EDUCATION & WELFARE
NATIONAL INSTITUTE OF EDUCATION

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Patricia Campbell & A.E. Virgin

July, 1976

This study was funded by the Ministry of Education
for the Province of Ontario under the Grants-in-Aid of
Educational Research Program

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Purpose

The purpose of the study was to compare the achievement, attitudes and teaching/learning experiences in mathematics programs of two groups of elementary school students at the grade 5 and 6 levels. One group of students utilized the mini-calculator in the mathematics program and the comparison group did not have access to the mini-calculator in school.

Background

In the past few years, as mini-calculators have become popular in the market place at increasingly lower cost to the consumer, North York educators and parents have raised questions regarding the implications of this development for school programs. Presently in North York, the mini-calculator is being used on a limited basis by a few Program Leaders working with small groups of students in grades 5 & 6 where their use has been confined to short-term, specific tasks.

Although some research has been done in this area, it is not extensive. The earliest reference found was an article by Lois Beck of the Riverside California School System, published some 15 years ago. On the basis of classroom observation of grade 4,5 and 6 pupils participating in a program using desk calculators, Beck concluded:

1. that elementary school children can readily learn to operate the calculator,
2. that when used as a regular classroom tool, the calculator tends to motivate and reinforce understanding and achievement in basic arithmetic skills,
3. that children seem to enjoy using the calculator and to become enthusiastic about arithmetic,
4. that use of the calculator seems to foster better work habits in the students (ie: accuracy and neatness; wise use of time; checking work; attentiveness and concentration).

Also supporting the positive effects of the calculator, Van Atta (1967) contends that many problems that cannot be done by the pupil alone can be handled by the pupil with the aid of a calculator, such as the intuitive approach to the laws of exponents, to Pythagoras' Theorem, to irrational numbers, to logarithms. The assumption made by Van Atta is that in order for the students to reach an intuitive level of understanding of these problems, he must do an incredible amount of computation, run the risk of error and so run the risk of mistaken conclusions. Aided by the calculator, however, he may reach an understanding more quickly and directly, may test many different relationships and may work out more interesting problems than without the calculator.

Advani (1972) conducted an experimental study in a special class of 18 adolescents with learning and behaviour problems, to determine the feasibility of using desk calculators in conjunction with mathematics instruction and further, to assess their effect on the achievement, attitudes and behaviour of these students. The results showed a significant difference

on pre-and post-test achievement scores and marked increases in student interest in and attitude towards mathematics. Advani concluded that the use of calculators can facilitate mathematics instruction in a special class, help release students' frustrations due to inaccessible numbers and help teachers in individualizing mathematics instruction.

Cech (1970) conducted a study with 100 ninth grade, low-achieving mathematics students to determine the effect of the use of desk calculators on student attitudes towards mathematics. During the seven-week program, instructional activities, assignments and time spent on mathematics were controlled for both research (50 students) and control groups (50 students). The experimental groups differed from the control groups in that they had the use of the calculator to check their work. Pre-test/post-test results did not show significant differences between the two groups in either attitude or computational skills. There was however, support for the hypothesis that students who used the calculators were able to compute better than students who did not have the assistance of the calculator. Cech points out the need for research conducted over periods of time of one or more years and an examination of the effect of calculators on the understanding of mathematics through illustration of mathematical principles and solutions of meaningful, but complex problems.

Hawthorne (1973) has described some of the advantages and disadvantages of the mini-calculator in school programs. He states that few changes should be necessary to an elementary school mathematics program which emphasizes understanding of concepts and a meaningful approach to computational logarithms. Since, in his opinion, calculators can make only fringe contributions to these areas, their use need not detract from the significance and relevance of these goals. He cites three related advantages of the hand-held calculator. One is the ability to provide immediate feedback to students on their work. Secondly, the calculator can eliminate tedious, unnecessary calculations that consume precious time and destroy interest. Thirdly, they can provide an important motivational factor in the work with and understanding of mathematics. Focusing on the potential disadvantages of the calculator, however, Hawthorne points to the fact that they permit students to get answers using operations that they have not yet studied and likely don't understand. If introduced too early, before the child has developed some "number-sense" and familiarity with the basic operations of arithmetic, calculators could do great harm - they do not, by themselves, help students to gain the understanding of basic number concepts generally considered necessary.

Denman (1974) describes the ways in which calculators can help to turn children on to education in mathematics classrooms. She suggests that the motivational impact on students may be sufficient reason to use small calculators at some times in certain classes. The calculating speed of the machine can stimulate able learners to solve long, complex problems, while allowing less able students to check the correctness of their computations quickly and thus gain confidence in their ability. According to Denman, the immediate feedback to the student is a principal contribution of the calculator to mathematics learning.

As is obvious, few people have systematically gathered evidence to document their opinions regarding the advantages and disadvantages of mini-calculators. Further, the two studies which did report both achievement and attitude results, involved the use of desk calculators with special students.

Hypotheses

It was hypothesized that students in the experimental school would show greater gains in their mathematics skills and attitudes than students in the comparison school.

Sample

The sample included approximately 150 grade 5 and 6 students in each of two North York elementary schools which were similar in terms of (a) the objectives of and time given to their mathematics programs and (b) the socio-economic character of the communities they served.

Procedure

Initially, a few parents in the community expressed some concern regarding their children's involvement in the study and the use of calculators in the mathematics program. The school therefore decided to hold a meeting for the parents in early September to acquaint them with the proposed study, to comment on available research on calculators and to answer any questions that parents might have. A letter, plus a booklet on mini-calculators, "Pocket Mini-Calculator Revolution", was sent home to every parent before the meeting.

Prior to the meeting children reported some of the comments their parents had made and some of their own reactions:

"My mom is dead set against me using one so I hope they change her mind at the meeting".

"After my parents read that booklet they liked the idea of using calculators more".

" I wish I could make the decision whether I should use the calculator".

After the meeting another letter was sent home to all parents of children in grades 5 and 6 asking them to vote on whether or not they wanted the project to be carried out. The results were 105 in favour, 47 against, and 2 undecided, out of a possible 160 votes.

On the basis of the favourable vote, it was decided to start the project and permission forms were sent home to the parents asking their consent for their children to participate in the program. The majority of parents agreed but each classroom had about five pupils whose parents had not agreed to their participation in the program. These pupils did the same work as the others, but did not use the calculator.

At the end of September, pupils in both the experimental and comparison schools were administered the Math Computation, Math Concepts and Problem Solving subtests of the Metropolitan Achievement Tests (MAT Intermediate, Form G) to obtain a baseline measure of their mathematical skills. Secondly, they were asked to complete a questionnaire (see Appendix A) regarding their attitudes toward mathematics and the use of mini-calculators in their mathematics program.

The school was given 50 calculators, ten per class, to use for the 1975-76 school year by the Mathematics Department. They had all the necessary functions for this grade level, ie. addition, subtraction, multiplication, division, floating decimal, two clearing keys (clear entry and clear) and a display of nine digits, as well as a rechargeable unit. As a security measure, the thirty calculators used in the open area were kept in a locked cupboard and the two teachers in the closed classrooms locked the ten calculators each of them had in their desk drawers. Thus no one had access to the calculators without the permission of the teachers.

Originally it was proposed that there would be only ten calculators per class, thereby providing a very controlled situation in which the students could use the machines. However, the classes were so large (averaging 38 students) that the teachers would borrow calculators from other classrooms with the result that there were as many as ten to twenty calculators in use at one time. The teachers consequently could not supervise all students as closely as was needed and on several occasions the students were observed trying to spell words onthe calculators or actually figuring the answer to a question instead of using it to check their work, as they had been instructed to do by their teachers.

At the end of April, post-testing was conducted and pupils again completed the three mathematics subtests of the MAT Intermediate, Form F and the attitude questionnaire.

The ten participating teachers were also asked to complete a brief questionnaire both in September and again in the spring, regarding their attitudes toward the use of mini-calculators and the teaching of mathematics.

Description of Program

Experimental School

Five mixed Grade 5/6 classes were involved in the Mini-Calculator study at the experimental school. Three classes were conducted in an open area and two in self-contained classrooms.

The three teachers who taught in the open area divided their classes into three groups according to the students' mathematical ability, based on the marks they had achieved during the previous year. One teacher took the students who were in the top third of each of the three classes (approximately 40), one took the middle or average students (approximately 38), and the other took the remaining students (approximately 24) who were the weakest group in mathematics. Four days a week the students would go to their respective groups at 9:30 a.m. and would return to their regular teacher again at 10:30. The three teachers in the open area seldom used the calculator during the four months from January to April as they could not incorporate it into their lessons.

The two teachers in the closed classroom held math classes every morning for approximately 45 - 60 minutes. They worked independently and did not mix classes as was done in the

open area. Although these teachers used the calculator more often than those in the open area, they did not do so on a regular or formal basis. For example, if a student wanted to check his work, he would get the teacher's permission to use the calculator and spend a few minutes operating it. Sometimes the students used the calculators when they were playing math games to calculate the answer faster and/or check their own calculations. Students used the calculator to compute the area or perimeter of large dimensions in the school, e.g. the area of the gymnasium, the perimeter of the playing field.

The teachers also used the calculator to motivate slower students in math. Several pupils were observed checking their math calculations on the calculator and expressed a keen interest. They would actually groan when the math period was over and they had to put the calculators away.

The four most important math objectives for the teachers were:

- developing students' competence in the basic operations
- encouraging students to enjoy numbers, explore new areas
- building students' confidence in their abilities
- developing independent thinkers

At the beginning of the year, four of the five teachers felt the calculator would be useful in helping them to achieve their objectives. At the end of the year, however, they were not quite as positive. While they felt that the calculator did not prevent them from reaching their objectives, they also felt that it did not facilitate the reaching of their objectives.

Although the teachers had never used calculators with their students before, at the beginning of the year two felt the mini-calculator did have a place in the math program, while three did not. In the spring, however, all five teachers felt the calculator did have some place in the program. For example:

. with strict controls it is an excellent motivational tool

. we need to develop more programs in which the calculator could be used. It's good for some parts of the program

Four of the five teachers felt that students should achieve a specified level of proficiency in computation before being allowed to use a calculator. For example, in two classes, students had to achieve over 80% on a test of computational skills before having access to the calculator. Teachers felt that students needed to understand the operations first, so that when they used the calculator they would have an idea of what the answer should be.

The following are advantages teachers felt the calculator had in their program:

- motivational tool
- students can do more work, therefore increases their experiences
- work can be completed faster
- good checking device

They also felt, however, that there were some disadvantages:

- it could become a crutch for students
- needed safeguards for effective use
- the teachers themselves need an in-service program on how to use them in their program

Comparison School

Two Grade 5 classes and three Grade 6 classes were involved in the study. The Grade 5 classes were conducted in an open area and the Grade 6 classes were in self-contained classrooms.

All the teachers taught mathematics to their students every day for approximately 45 - 60 minutes.

Each teacher had their own program and conducted his math classes independently from the other teachers. For example, three teachers used student marks from the previous year and the results of the September pre-test to divide their class into several different groups according to their mathematical ability.

Another teacher let the students in the class work independently most of the time from their textbook and would occasionally teach a formal lesson. Another teacher would teach a lesson to the whole class as one group.

The four major objectives for teachers in the comparison school were as follows:

- developing students' competence in the basic operations
- encouraging students to enjoy numbers, explore new areas
- stimulating an interest in numbers and problem-solving
- encouraging students to apply their knowledge to everyday life

Results

The results are presented in three sections: Achievement, Attitudes and Teacher Questionnaire. *

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* For further information re teacher attitudes toward mini-calculators see Campbell, P., & Virgin, A.E. "A Survey of Elementary School Teachers' and Principals' Attitudes to Mathematics and Utilizing Mini-Calculators". July, 1976.

Achievement

Data on the Metropolitan Achievement Test are presented in the following sets of tables for each of grades 5 & 6.

SUBTEST COMPUTATION

GRADE 5

	PRE-TEST			POST-TEST			GAIN		
	Actual Mean	Expect. g.e.	N	Actual Mean	Expect. g.e.	N	Mean	Std. Dev.	N
EXPERIMENTAL	5.2	5.0	54	6.0	5.7	54	0.80	0.90	54
COMPARISON	5.3	5.0	61	6.2	5.7	54	0.87	0.84	54

In the fall, both schools' results on the computation subtest were similar and were above the expected mean. In the spring, the experimental and comparison schools' results were higher than in the fall and both were above the expected mean. There were no significant differences in the gain scores between the two schools.

GRADE 6

	PRE-TEST			POST-TEST			GAIN		
	Actual Mean	Expect. g.e.	N	Actual Mean	Expect. g.e.	N	Mean	Std. Dev.	N
EXPERIMENTAL	6.2	6.0	67	6.9	6.7	67	0.70	0.95	67
COMPARISON	6.5	6.0	89	7.2	6.7	78	0.62	0.82	77

The Grade 6 students' results in both schools were above the expected mean for this subtest in the fall and in the spring. Although the comparison school students' results were slightly higher on both the pre- and post-test, the difference between the gain scores was not significant.

SUBTEST MATH CONCEPTS

GRADE 5

	PRE- TEST			POST - TEST			GAIN		
	Actual Mean	Expect. g.e.	N	Actual Mean	Expect. g.e.	N	Mean	Std. Dev.	N
EXPERIMENTAL	4.9	5.0	55	6.3	5.7	55	1.4*	1.0	55
COMPARISON	5.0	5.0	61	6.0	5.7	53	1.0	1.1	54

* ($t = 2.5$, $df = 107$, $p < .05$; Critical $t = 1.65$).

Although there was little difference between the average scores obtained by the two groups in the fall, the gain score for the experimental group was significantly higher than that for the comparison group.

GRADE 6

	PRE-TEST			POST-TEST			GAIN		
	Actual Mean	Expect. g.e.	N	Actual Mean	Expect. g.e.	N	Mean	Std. Dev.	N
EXPERIMENTAL	5.8	6.0	71	7.3	6.7	71	1.5	1.3	71
COMPARISON	5.8	6.0	89	7.3	6.7	74	1.5	1.2	73

There was no difference between the two groups in terms of their gain scores on the math concepts subtest. The reader will also note that although both groups were below the expected grade equivalent in the fall, by the spring, both groups on the average were performing at a level six months above the expected grade equivalent for the time of testing.

SUBTEST PROBLEM SOLVING

GRADE 5

	PRE-TEST			POST-TEST			GAIN		
	Actual Mean	Expect. g.e.	N	Actual Mean	Expect g.e.	N	Mean	Std. Dev.	N
EXPERIMENTAL	5.4	5.0	54	6.0	5.7	54	0.53*	1.14	54
COMPARISON	5.6	5.0	59	5.6	5.7	53	0.0	1.10	51

* Gain score differences significant ($t = 2.7$, $df = 103$. $p < .05$; critical $t = 1.65$)

Gain scores for the experimental students were significantly higher than those for the comparison students. The reader will note that these results are attributable to the fact that the comparison students showed no growth from fall to spring, while the experimental students showed an average growth of five months.

GRADE 6

	PRE-TEST			POST-TEST			GAIN		
	Actual Mean	Expect. g.e.	N	Actual Mean	Expect. g.e.	N	Mean	Std. Dev.	N
EXPERIMENTAL	6.4	6.0	72	6.9	6.7	72	0.43	1.07	72
COMPARISON	6.6	6.0	90	7.1	6.7	74	0.32	1.00	74

At the Grade 6 level, there was no difference between the two groups in terms of their average gain scores on the problem-solving subtest.

Student Attitudes

The student attitude questionnaires were analyzed by grade for each school. A comparison was made between their fall and spring responses to determine if there were any changes in attitudes toward mathematics and mini-calculators. There were 66 Grade 5 and 91 Grade 6 returns in the experimental school in the fall, and 67 Grade 5 and 92 Grade 6 returns in the spring. In the comparison school the number of completed questionnaires was 62 Grade 5 and 89 Grade 6 in the fall, and 61 Grade 5 and 85 Grade 6 in the spring. For analysis purposes, the questions that had five categories describing the students' attitudes, were collapsed to three.

Results for Grade 5 Pupils

Do you like doing mathematics?

	A Lot		So/So		Not Much	
	Fall %	Spring %	Fall %	Spring %	Fall %	Spring %
EXPERIMENTAL	39	46	50	42	14	12
COMPARISON	69	65	26	29	5	5

It is evident that more students in the comparison school enjoyed doing mathematics than the experimental students on both the fall and spring questionnaires. However, there was a change in the attitudes of the experimental students over the course of the year in a positive direction. In the spring, more students reported liking mathematics "a lot" and fewer students indicated little liking for math.

Two similar questions were included in the questionnaire to check the validity of the students' responses, ie. "How well do you do in mathematics?" and "How good are you at doing mathematics?" A comparison of the responses to the two questions indicates a very similar pattern.

How good are you at doing Mathematics?

	Good		So/So		Not Very Good	
	Fall %	Spring %	Fall %	Spring %	Fall %	Spring %
EXPERIMENTAL	56	64	33	33	9	3
COMPARISON	82	82	16	11	2	7

How well do you do in Mathematics?

	Well		So/So		Not Very Well	
	Fall %	Spring %	Fall %	Spring %	Fall %	Spring %
EXPERIMENTAL	62	60	32	34	7	6
COMPARISON	79	80	18	15	2	5

In both fall and spring, a larger percent of the comparison school students stated that they did well in mathematics than students in the experimental school. Nearly one-third of the experimental school students on both the fall and spring tests felt their performance was average, ie. "so/so" as compared to less than twenty percent in the comparison school.

It is interesting to note that in terms of the spring results on the mathematics achievement tests, the experimental school obtained higher average scores on two of the three subtests. Therefore, while in fact the experimental students are performing slightly better than the comparison students, fewer of them report liking mathematics and perceive themselves as doing well as compared with the comparison students.

What do you find is easiest about doing mathematics?

COMMENT	Number of Students			
	Experimental		Comparison	
	Fall	Spring	Fall	Spring
Addition	40	33	29	20
Subtraction	13	15	16	18
Multiplication	14	11	12	5
Division	11	9	14	7
Fractions		7		7
Decimals		10		3
Timestables	5	5		0
Ratio		4		0
Geometry		1		3
Everything		1		9
Other		5		5
No Answer	2	2	2	2

On both the fall and spring questionnaires, the students in both groups indicated that they found the basic operations to be the easiest in mathematics. In the spring, students in both schools listed a greater variety of responses to this question.

What do you find hardest about doing mathematics?

COMMENT	Number of Students			
	Experimental		Comparison	
	Fall	Spring	Fall	Spring
Division	31	15	32	16
Fractions	9	9	2	5
Multiplication	8	11	14	6
Decimals		13		1
Percent		5		1
Geometry		5		1
Timestables		1		1
Tests		2		6
Nothing	9	6	4	10
Other	1	3	1	4
No Answer	2	1	1	9

In the fall and spring, both schools found division to be the hardest operation in mathematics to perform. The experimental students listed fractions as the next hardest, whereas the

comparison school students chose multiplication. Quite a few students in both schools said that they did not find anything difficult about mathematics. As in the previous question, there was a greater variety of responses in the spring.

Which one of the following subjects do you like doing the best?

	Mathematics			Reading			Science			Social Studies		
	Fall	Spring	Gain	Fall	Spring	Gain	Fall	Spring	Gain	Fall	Spring	Gain
EXPERIMENTAL	30	25	-5	39	40	1	26	27	1	4	7	3
COMPARISON	42	38	-4	32	34	2	18	18	0	8	8	0

The experimental students liked reading best, followed by mathematics, whereas for the comparison students it was vice-versa. Both groups showed a slight decline from fall to spring, in terms of the percent of pupils indicating that they liked math best.

Which one of the following subjects do you like doing the least?

	Mathematics			Reading			Science			Social Studies		
	Fall	Spring	Gain	Fall	Spring	Gain	Fall	Spring	Gain	Fall	Spring	Gain
EXPERIMENTAL	26	19	-7	21	16	-5	14	22	8	38	37	-1
COMPARISON	21	11	-10	21	20	1	29	25	-4	24	44	10

About 26% of the experimental students said mathematics was the most disliked subject in the fall, but in the spring their dislike shifted to science. In the fall, the comparison school students were fairly evenly split between reading, mathematics and social studies, as subjects they liked least, however, in the spring, only 11% of the comparison students selected math as the subject they liked least.

Which one of the following subjects do you like doing the best?

	Mathematics			Physical Education			Art			Music		
	Fall	Spring	Gain	Fall	Spring	Gain	Fall	Spring	Gain	Fall	Spring	Gain
EXPERIMENTAL	6	13	7	35	49	14	45	25	-20	14	12	-2
COMPARISON	27	21	6	27	28	1	35	38	3	10	13	3

When compared to physical education, art and music, math ranked fourth as being the best liked subject for experimental students in the fall. Although in the spring there was an increase in the percent of experimental pupils selecting math, it still ranked far below physical education and art.

In the comparison school on the other hand, math and physical education respectively, were selected by approximately 27% of the pupils as the subject they liked best, thus ranking second among this group of subjects. In the spring, there was a decline in the percent of students selecting math, although 20% still indicated that they liked it best when compared to physical education, art and music.

Which one of the following subjects do you like doing the least?

	Mathematics			Physical Educ.			Art			Music		
	Fall	Spring	Gain	Fall	Spring	Gain	Fall	Spring	Gain	Fall	Spring	Gain
EXPERIMENTAL	36	22	-14	6	9	3	17	22	5	39	46	7
COMPARISON	16	18	2	26	31	5	13	11	2	43	39	-4

Approximately one-third of the experimental students indicated in the fall that they liked math least, while in the spring, only 22% selected math as their least favourite subject. In the comparison school, in both fall and spring, approximately 16-18% selected math as the subject they liked least. It is evident from this first group of items, that in general, students in the comparison school have slightly more positive attitudes toward math than students in the experimental school.

In the next set of questions, students were asked how important it was for them to be good at performing various arithmetical operations, eg. adding, subtracting, multiplying and dividing. The percent of students in each group who felt it was "very important" or "important" is shown in the following table.

	EXPERIMENTAL		COMPARISON	
	Fall %	Spring %	Fall %	Spring %
Adding	95	95	89	98
Subtracting	91	96	93	88
Multiplying	98	100	89	98
Dividing	92	98	90	95

It is obvious that pupils feel it is important to be able to carry out basic arithmetic operations well. Although for the most part there was relatively little change in the responses of the experimental students from fall to spring, in the comparison school, slightly more students felt this was important in the spring than in the fall.

In both fall and spring, over 95% of the students in both groups felt that it was important to their parents for them to do well in mathematics.

What do you like the most about mathematics?

Comment	Number of Students			
	Experimental		Comparison	
	Fall	Spring	Fall	Spring
Addition	27	17	17	7
Multiplication	11	10	18	11
Division	11	11	13	10
Subtraction	10	11	12	4
Fractions		6	3	6
Decimals		7		6
Percent		2		
Ratio		5		
Geometry				4
Times tables	6	2		2
Everything	4	1	3	4
Other		12		7
No Answer		6	5	7

The four basic operations were the most popular responses to this question from both schools. A few students said that they liked 'everything'. As in previous questions of this nature, there was a greater variety of comments in the spring than in the fall.

What do you like the least about mathematics?

	Number of Students			
	Experimental		Comparison	
	Fall	Spring	Fall	Spring
Division	20	10	22	14
Multiplication	12	11	6	11
Subtraction	7	5	7	8
Addition	2	1	10	4
Fractions	3	10	1	4
Decimals		7		5
Times tables	5	3		
Percent		5		
Geometry		3		
Nothing		8		6
Other		8		5
No Answer		2	10	4

Although the students stated in the previous question that they liked the basic operations the most, they are also the operations mentioned most frequently as being disliked. Perhaps this is a reflection of the fact that students are most familiar with these operations.

Up to this point, we have discussed pupils' attitudes toward mathematics. In the next set of questions, pupils were asked whether or not they had a pocket calculator and what they thought of it.

In the fall, 41% of the experimental students reported having a pocket calculator in their home, whereas in the spring, 58% of the students had a calculator at home. For the comparison school, the percentages were 37% and 50%, respectively.

Students were also asked whether they had their own calculator. No one in the experimental school said that he owned a calculator in the fall, and only one student in the comparison school had a calculator of his own.

In the spring however, 10% of the experimental school students and 15% of the comparison students indicated that they now had their own calculator.

How long have you had one?

COMMENT	Number of Students			
	Experimental		Comparison	
	Fall	Spring	Fall	Spring
One month or less	3	4	0	4
Two to five months		12	1	9
Six months to 1 year	6	7	4	6
Two or more years	3	8	5	9
No Answer	58	36	48	32

The majority of the students did not answer this question because most did not have a calculator. Of the few students who did have one, most had had them for half a year to one year, or had had them for more than two years. In view of the fact that in the fall, only one student reported owning a calculator of his own, the responses to this question probably refer to a calculator owned by the family, not the student himself.

Over half of the students in each school did not answer the question regarding frequency of using a calculator either in the fall or in the spring. However, those students who had a calculator and did respond to the question indicated that they hardly ever used it. This was the case in both the experimental and comparison schools.

Approximately 50% of the experimental students had not used a pocket calculator before September, while one-third of the comparison students had not done so.

In response to the question, "What did you use your calculator for?", 54% of the experimental students who responded in the spring indicated they used it for school work, as compared to 38% of the respondents in the fall. Sixty percent of the comparison school respondents in the spring said they used their calculator for school work, almost the same percentage (67%) who said they used it for school work in the fall. Forty-two percent and 31% of the experimental and comparison school respondents, respectively, indicated they used the calculator to play or experiment with.

Why do you think people use pocket calculators?

COMMENT	Number of Students			
	Experimental		Comparison	
	Fall	Spring	Fall	Spring
To help them with math	26	27	28	24
It's faster	8	19	8	23
To do hard questions	6	7	9	4
For their jobs, bills	5	6	1	2
They are lazy, dumb	3	4		2
To prevent mistakes		2	1	
Other		2		1
No Answer	7	2	8	5

The majority of students felt that people use calculators to facilitate doing tasks involving mathematics.

In the fall, most (82%) of the experimental students thought that a pocket calculator would be helpful for doing mathematics, although less than half (47%) of the students in the comparison school agreed. The experimental students were aware at the time of completing the questionnaire that mini-calculators were going to be used in their math program, which perhaps explains the large difference between the two groups regarding their perceptions of how helpful pocket calculators could be. In the spring, however, it is obvious that the high expectations regarding the calculator were not met as only 42% of the experimental students felt that calculators were helpful for doing mathematics. The perceptions of the comparison group also changed, with only 34% feeling in the spring that calculators would be helpful.

Reasons given as to why pupils feel the calculator would or would not be helpful are summarized in the following table.

Comment	Number of Students			
	Experimental		Comparison	
	Fall	Spring	Fall	Spring
If Yes,				
1. It helps you	8	6	10	3
2. To learn more	12	7		1
3. To check work	17	5	3	3
4. It's quick, saves time		2	2	9
5. Helps teacher - has less marking to do	4	4		
6. It gives you the answer	6	2		4
7. Only in secondary school		1		
If No,				
1. You don't learn, they're "no good"	6	13	21	14
2. Won't use your brain		9	2	5
3. You would depend on calculator. It would do your work		6	1	5
4. You should learn math without a calculator		6		5
5. You would cheat with it		2		6
Other		5		3
No Answer	7	2	8	5

How good do you think you should be at doing mathematics before you use a pocket calculator?

	Good		So/So		Not Good	
	Fall	Spring	Fall	Spring	Fall	Spring
	%	%	%	%	%	%
Experimental	79	89	15	6	4	4
Comparison	71	84	14	8	10	6

In the fall approximately three-quarters of both schools felt that you should be quite good in mathematics before you use a pocket calculator, while in the spring, approximately 85% felt that you should be quite good.

When asked "Why?" approximately half of the students did not respond. Responses of the remaining students are summarized in the following table.

Comment	Number of Students			
	Experimental		Comparison	
	Fall	Spring	Fall	Spring
1. If you 're good, you don't need a calculator		14	11	8
2. Will depend on calculator, should know math first		14		
3. Must be good or else you can't improve	16	3		6
4. If you're good, will help when you're without a calculator	9	2	1	2
5. If you're good, you can check calculator's answers		1	4	2
6. Will dull brain if use too much and then wouldn't learn	2	1		3
Other				
No Answer	32	36	37	36

In the fall, 65% of the experimental students and 52% of the comparison students stated that they thought they would do better in mathematics if they used a pocket calculator.

In the spring, however, approximately 40% of the students felt that a calculator would help them to do better in math.

When asked "Do you think pocket calculators ever make a mistake?" 44% of the experimental students and 56% of the comparison students answered "Yes" in the fall. In the spring, however, 69% of the experimental students answered "Yes", while the percent of pupils in the comparison school remained almost the same.

In response to the question, "Do you think it is a good idea for people to use a pocket calculator?", half of the comparison group said "Yes" in both fall and spring. Among the experimental students, however, 70% said "Yes" in the fall and only 60% in the spring.

The most popular comment given by those students who thought it was a good idea for people to use calculators was that "it helped them". Others thought you could do questions faster and others stated you would learn more.

The main reasons why people shouldn't use calculators were that you wouldn't learn anything and that you could become dependent on the calculator and let it do the work for you.

Comment	Number of Students			
	Experimental		Comparison	
	Fall	Spring	Fall	Spring
If Yes,				
1. It helps you	10	18	12	4
2. Can do questions faster	6	13	5	15
3. You would learn more	7	5		1
4. Adults need it for business, bills, etc.		2	4	3
5. To check work	3	3		4
If No,				
1. You won't learn	2	12	8	14
2. Will depend on calculator - then not doing it yourself	3	7	9	9
3. It's not good for everyone	6			
Other		5		4
No Answer	20	4	17	8

Results for Grade 6 Pupils

Do you like doing mathematics?

	A Lot		So/So		Not Much	
	Fall	Spring	Fall	Spring	Fall	Spring
	%	%	%	%	%	%
EXPERIMENTAL	53	60	32	30	15	10
COMPARISON	56	58	39	33	3	9

In the fall slightly more students in the comparison school said they liked doing mathematics a lot, while in the spring, slightly more of the experimental school students responded in this way.

How well do you do in mathematics?

	Well		So/So		Not Very Well	
	Fall	Spring	Fall	Spring	Fall	Spring
	%	%	%	%	%	%
EXPERIMENTAL	74	71	18	25	8	4
COMPARISON	69	67	27	23	3	9

In both fall and the spring, more of the experimental students stated that they did better in mathematics than students in the comparison school. There was little change in either group between the two administrations of the questionnaire.

How good are you at doing mathematics?

	Good		So/So		Not Very Good	
	Fall	Spring	Fall	Spring	Fall	Spring
	%	%	%	%	%	%
EXPERIMENTAL	68	68	23	27	10	4
COMPARISON	76	66	20	27	3	6

Although the responses for the experimental students were very similar on both the fall and spring administrations, there was some change from fall to spring for the comparison students.

What do you find is easiest about doing mathematics?

Comment	Number of Students			
	Experimental		Comparison	
	Fall	Spring	Fall	Spring
Addition	49	41	47	33
Subtraction	24	23	37	26
Multiplication	22	18	27	25
Division	26	14	12	20
Decimals		12		5
Fractions		11		12
Times tables	8	6		8
Ratio		6		3
Geometry		3		2
Learning & Understanding		1		6
Everything		8		3
Other		6		10
No Answer	2	2	7	2

On both the fall and spring questionnaires, the students in both schools indicated that they found the basic operations to be the easiest part about doing mathematics. As was the case in grade 5, students listed a greater variety of responses to this question in the spring.

What do you find is hardest about doing mathematics?

Comment	Number of Students			
	Experimental		Comparison	
	Fall	Spring	Fall	Spring
Division	21	21	32	16
Fractions	21	[illegible]	14	25
Decimals		10		5
Multiplication	13	8	10	4
Percent		9		6
Geometry		5		11
Times tables		7		1
Tests		4		2
Subtraction	2	1	4	
Adding	2		2	
Other		11		16
No Answer	4	4	10	4

In the fall, students in both schools stated that division was the hardest part about doing mathematics and fractions was the next hardest. In the spring, division was the hardest operation for the experimental students and fractions were the most difficult for the comparison students.

Which one of the following subjects do you like doing the best?

	Mathematics			Reading			Science			Social Studies		
	Fall	Spring	Gain	Fall	Spring	Gain	Fall	Spring	Gain	Fall	Spring	Gain
	%	%	%	%	%	%	%	%	%	%	%	%
Experimental	36	35	-1	36	30	-6	20	20	0	7	14	+7
Comparison	29	27	-2	34	34	0	22	21	-1	12	13	+1

In the fall both groups of students liked doing reading and mathematics the best, whereas in the spring, mathematics was the first choice of the experimental students. The comparison school students liked reading the best and chose mathematics as their next choice.

Which one of the following subjects do you like doing the least?

	Mathematics			Reading			Science			Social Studies		
	Fall	Spring	Gain	Fall	Spring	Gain	Fall	Spring	Gain	Fall	Spring	Gain
	%	%	%	%	%	%	%	%	%	%	%	%
Experimental	16	11	-5	24	16	-8	24	27	+3	33	46	+13
Comparison	11	22	+11	28	26	-2	27	14	-13	33	36	+3

In the fall, both groups indicated that math was their fourth choice among science, reading, social studies and math as the subject they liked least. In the spring, the experimental group still ranked math as their fourth choice, while the comparison group now ranked it as their third choice.

Which one of the following subjects do you like doing the best?

	Mathematics			Physical Educ.			Art			Music		
	Fall	Spring	Gain	Fall	Spring	Gain	Fall	Spring	Gain	Fall	Spring	Gain
	%	%	%	%	%	%	%	%	%	%	%	%
EXPERIMENTAL	7	14	7	48	48	0	34	24	-10	11	13	2
COMPARISON	26	22	-4	26	36	10	36	26	-10	12	14	2

When compared to music, physical education and art, the experimental students ranked math fourth as the subject they liked best in the fall, while the comparison students ranked it equally with physical education. In the spring, the experimental students viewed math somewhat more positively than in the fall, but physical education and art were still selected by a larger percent of students as subjects they liked best.

Which one of the following subjects do you like doing the least?

	Mathematics			Physical Educ.			Art			Music		
	Fall	Spring	Gain	Fall	Spring	Gain	Fall	Spring	Gain	Fall	Spring	Gain
	%	%	%	%	%	%	%	%	%	%	%	%
EXPERIMENTAL	27	24	-3	12	10	-2	15	16	1	42	47	5
COMPARISON	22	18	-4	21	26	5	21	15	-6	34	41	7

On the fall and spring questionnaires, students in both schools indicated that they disliked music the most. The experimental school students chose mathematics as their second most disliked subject on both tests, however the comparison school students shifted from mathematics in the fall to physical education in the spring.

Students were then asked more specific questions regarding their perceptions of the importance of being good at performing basic arithmetical operations. The following table outlines the percent of students who felt it was "important" or "very important" to be good at adding, subtracting, multiplying and dividing.

	EXPERIMENTAL		COMPARISON	
	Fall	Spring	Fall	Spring
	%	%	%	%
Adding	88	97	94	98
Subtracting	91	94	88	94
Multiplying	94	99	97	96
Dividing	93	98	92	96

It is obvious that the majority of grade 6 students felt it was important to be able to perform basic arithmetic operations well. Furthermore, in both fall and spring, over 95% of the students in each group felt that it was important to their parents that they did well in mathematics.

What do you like the most about mathematics?

Comment	Number of Students			
	Experimental		Comparison	
	Fall	Spring	Fall	Spring
Addition	24	16	21	15
Multiplication	24	20	24	14
Division	25	11	12	13
Subtraction	11	7	17	14
Decimals		16		6
Geometry		6		7
Times tables	3	3		6
Ratio		3		5
Percent				3
Fractions		7	4	9
Everything	8	6	11	9
Other		20		15
No Answer		6	10	12

The four basic operations were the most popular responses to this question in both the fall and spring. Quite a few students said they liked everything.

What do you like the least about mathematics?

Comment	Number of Students			
	Experimental		Comparison	
	Fall	Spring	Fall	Spring
Division	18	17	24	6
Fractions	13	8	17	21
Multiplication	10	10	14	6
Subtraction	8	4	15	8
Times tables	8	6		1
Percent		7		6
Decimals		6		4
Geometry		3		12
Addition	5	1	4	2
Work		1		2
Nothing		16		11
Other		13		8
No Answer		7	17	7

Both schools' responses showed that division was the least liked part of mathematics in the fall. In the spring, the experimental students still stated that division was not their favourite part of mathematics, while the comparison students chose fractions as the most unpopular operation.

The following set of questions pertains to pocket calculators themselves.

In the fall approximately 40% of the students in both schools said that they had a pocket calculator in their home. By the spring approximately sixty percent of the students now had pocket calculators available to them in their home.

In the fall approximately 6% of the students in both schools stated that they owned their own pocket calculator. In the spring, 13% of the experimental students and 9% of the comparison students indicated that they now had their own calculators.

How long have you had one?

COMMENT	Number of Students			
	Experimental		Comparison	
	Fall	Spring	Fall	Spring
1 month	4	2		3
2 months - 5 months		21	7	8
6 months - 1 year	9	8	4	16
2 or more years	4	12	5	7
Other		1		3
No Answer	58	36	70	48

The majority of the students did not answer this question because most did not have a pocket calculator. Most of the experimental and comparison students who had a calculator stated that they had had the calculator for less than a year. A few had had one for two or more years.

When asked how often they used their calculator, approximately half of the students did not respond. Those who did,indicated that they did not use the calculator very often. The number of students not using their calculator increased from the fall to the spring in both schools.

Approximately 60% of both groups indicated that they had used a pocket calculator before September.

The number of students in both schools using the calculator for school work increased from the fall to the spring. Sixteen percent of the experimental students used it for school work in the fall and 21% in the spring. The number of students in the comparison school using the calculator for school work increased from 19% in the fall to 22% in the spring.

However, the most prevalent use of the calculator in both schools was one of experimentation and play.

Why do you think people use pocket calculators?

Comment	Number of Students			
	Experimental		Comparison	
	Fall	Spring	Fall	Spring
It's faster	31	34	15	24
Helps them with math	23	33	31	27
To check work			7	
Use for bills, jobs	6	8	8	9
People are lazy	3	5		11
Prevent mistakes		1		6
To do hard questions	8	6	6	9
Other		2		
No Answer	12	6	8	6

As at the grade 5 level, the majority of grade 6 students felt that people use calculators to facilitate doing tasks involving mathematics, because it is faster.

In the fall, before the experiment began, 70% of the experimental students felt that a calculator would be helpful for doing mathematics in school. In the spring, however, after 7 months in which the calculators were available, only 45% of the students felt that calculators would be helpful. Obviously all of their expectations about calculators were not met. In the comparison school, 40% in the fall and 35% in the spring felt that calculators could be helpful. Reasons given by students as to why calculators would or would not be helpful are summarized in the following table.

Comment	Number of Students			
	Experimental		Comparison	
	Fall	Spring	Fall	Spring
	%	%	%	%
If Yes,				
It's faster - saves time	9	10	12	6
It helps you	11	6	6	4
To learn more	18	4	3	2
To check work	10	5		2
It gives you the answer	2			3
Helps the teacher - less marking	3	6		
It does hard questions		5		3
You can memorize from calculator		1		2
If No,				
You don't learn, they're no good	10	12	26	30
Won't use your brain		11	4	11
Depend on calculator to do your work for you		11	14	8
Should learn math without calculator		5		5
Other		6		5
No Answer	11	10	10	6

How good do you think you should be at doing mathematics before you use a pocket calculator?

	Good		So/So		Not Good	
	Fall	Spring	Fall	Spring	Fall	Spring
	%	%	%	%	%	%
Experimental	77	92	14	4	3	3
Comparison	75	82	10	11	9	6

In the fall, three-quarters of the students in each group felt that you should be quite good in mathematics before you use a pocket calculator.

In the spring, 92% of the experimental and 82% of the comparison students now felt you should

be good in math before being able to use a calculator. When asked "Why?" half of the students did not respond. Responses of the remaining students are summarized in the following table.

Comment	Number of Students			
	Experimental		Comparison	
	Fall	Spring	Fall	Spring
If you're good, don't need a calculator		10	10	10
You can't improve if you don't know math well	14	9		14
Will depend on calculator - should know math first		11		
If you're good this will help when we don't have a calculator	14	1	10	9
Will dull brain if use too much, then won't learn	10		7	6
If good can check calculator's answers		2	3	7
Only need it for hard questions		1		3
Doesn't take much to push a button				1
No Response	32	58	42	35

In the fall, 55% of the experimental students and 40% of the comparison students said that they would do better in mathematics if they used a pocket calculator. However, in the spring only 37% of the experimental and 33% of the comparison students felt that they would do better in math by using a calculator.

When asked "Do you think pocket calculators ever make a mistake?" 48% of the experimental students and 53% of the comparison students answered "Yes" in the fall. In the spring the percent of pupils answering "Yes", increased for both experimental (60%) and comparison (65%) students.

In both the fall and in the spring, two-thirds of the experimental school students thought it was a good idea for people to use a pocket calculator, while on both administrations of the questionnaire, 43% of the comparison students felt this was a good idea. Reasons given as to why people should use calculators are summarized in the following table.

Reasons why people should or should not use calculators	Number of Students			
	Experimental		Comparison	
	Fall	Spring	Fall	Spring
If Yes,				
Can do questions faster	16	19	6	13
It helps you	17	10	11	9
Can learn more	6	5		1
For checking	4	-		
Adults need it for bills and their jobs		2	7	10
They are lazy				2
If No,				
You will become lazy	4			
You wouldn't learn anything, will cheat	9	9	14	22
Will depend on it too much		10	14	11
It's not good for everyone	6			3
Don't need one if good at math		6		5
Other		6		5
No Answer	12	10	16	12

Teacher Questionnaire

As the responses of the participating teachers to many questions in the questionnaire were similar to those of the Borough-wide sample of teachers, they are not repeated in this section. The reader is directed to the complementary report by Campbell and Virgin (1976) for a full description of the results of the teacher questionnaire. The following is a brief summary of selected questionnaire items.

The teachers in both the experimental and comparison schools were similar in terms of their number of years of experience. Half the teachers in each group both taught for 2-5 years and the remaining teachers for 6-10 years. All of the teachers in each group reported enjoying teaching mathematics "very much" or "quite a bit".

In the fall, four of the five teachers in each group reported that most of their pupils also enjoyed mathematics. In the spring, however, they were not quite so positive. For example, in the experimental school only two of the five teachers felt that most of their pupils enjoyed math, one felt that "about half of them" enjoyed math and two did not respond to the question. In the comparison school, two teachers felt that most of their pupils enjoyed math, two felt "about half of them" enjoyed math and one teacher did not respond.

Teachers were also asked to indicate how many of their pupils were competent in the fundamentals of mathematics. The following table summarizes their responses.

	Most of Them		None of Them		No Answer	
	Fall	Spring	Fall	Spring	Fall	Spring
EXPERIMENTAL	3	3	2	1	-	1
COMPARISON	2	5	3	-	-	-

The reader will note that while in the spring all the comparison teachers felt that most of their pupils were competent in the fundamentals, in the experimental school, there was still one teacher who felt that none of the pupils was competent.

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APPENDIX A

MATH QUESTIONNAIRE

NAME: _____

SCHOOL: _____

GRADE: _____ CLASS: _____

DIRECTIONS:

ON THE FOLLOWING PAGES ARE A SERIES OF QUESTIONS ABOUT MATHEMATICS. PLEASE READ EACH QUESTION CAREFULLY AND CIRCLE THE ANSWER THAT DESCRIBES HOW YOU FEEL. THERE ARE NO RIGHT OR WRONG ANSWERS ON THIS QUESTIONNAIRE.

THE BOARD OF EDUCATION FOR THE BOROUGH OF NORTH YORK

Department of Educational Research & Development

1. DO YOU LIKE DOING MATHEMATICS?

(a) Very much (b) Quite a lot (c) So/So (d) Not very much (e) Not at all

2. HOW WELL DO YOU DO IN MATHEMATICS?

(a) Very well (b) Fairly well (c) So/So (d) Not very well (e) Poorly

3. WHAT DO YOU FIND IS EASIEST ABOUT DOING MATHEMATICS?

_____

_____

_____

4. WHAT DO YOU FIND IS HARDEST ABOUT DOING MATHEMATICS?

_____

_____

_____

5. WHICH ONE OF THE FOLLOWING SUBJECTS DO YOU LIKE DOING THE BEST?

(a) Science (b) Reading (c) Mathematics (d) Social Studies

6. WHICH ONE OF THE FOLLOWING SUBJECTS DO YOU LIKE DOING THE LEAST?

(a) Science (b) Reading (c) Mathematics (d) Social Studies

7. WHICH ONE OF THE FOLLOWING SUBJECTS DO YOU LIKE DOING THE BEST?

(a) Music (b) Physical Education (c) Mathematics (d) Art

8. WHICH ONE OF THE FOLLOWING SUBJECTS DO YOU LIKE DOING THE LEAST?

(a) Music (b) Physical Education (c) Mathematics (d) Art

9. HOW GOOD ARE YOU AT DOING MATHEMATICS?

(a) Very good (b) Fairly good (c) So/So (d) Not very good (c) Poor

10. HOW IMPORTANT DO YOU THINK IT IS FOR YOU TO BE GOOD AT ADDING?

(a) Very important (b) Quite important (c) So/So (d) Not very important

(e) Not at all important

11. HOW IMPORTANT DO YOU THINK IT IS FOR YOU TO BE GOOD AT SUBTRACTING?

(a) Very important (b) Quite important (c) So/So (d) Not very important

(e) Not at all important

12. HOW IMPORTANT DO YOU THINK IT IS FOR YOU TO BE GOOD AT MULTIPLYING?

(a) Very important (b) Quite important (c) So/So (d) Not very important

(e) Not at all important

13. HOW IMPORTANT DO YOU THINK IT IS FOR YOU TO BE GOOD AT DIVIDING?

(a) Very important (b) Quite important (c) So/So (d) Not very important

(e) Not at all important

14. HOW IMPORTANT IS IT TO YOUR PARENTS, THAT YOU DO WELL IN MATHEMATICS?

(a) Very important (b) Quite important (c) So/So (d) Not very important

(e) Not at all important

15. WHAT DO YOU LIKE THE MOST ABOUT MATHEMATICS?

16. WHAT DO YOU LIKE THE LEAST ABOUT MATHEMATICS?

_____

_____

PART B

17. DO YOU HAVE A POCKET CALCULATOR IN YOUR HOME?

(a) Yes (b) No

18. DO YOU HAVE A POCKET CALCULATOR OF YOUR OWN?

(a) Yes (b) No

19. HOW LONG HAVE YOU HAD ONE? _____

20. HOW OFTEN DO YOU USE IT? _____

21. BEFORE SEPTEMBER HAD YOU EVER USED A POCKET CALCULATOR?

(a) Yes (b) No

22. WHAT DID YOU USE IT FOR?

_____

_____

23. WHY DO YOU THINK PEOPLE USE POCKET CALCULATORS?

_____

_____

24. DO YOU THINK A POCKET CALCULATOR WOULD BE HELPFUL FOR DOING MATHEMATICS IN SCHOOL?

(a) Yes (b) No

WHY? _____

_____

_____

25. HOW GOOD DO YOU THINK YOU SHOULD BE AT DOING MATHEMATICS BEFORE YOU USE A POCKET CALCULATOR?

(a) Very good (b) Fairly good (c) All right/ not bad (d) Not very good

(e) Poor

WHY? _____

_____

_____

26. DO YOU THINK YOU WOULD BE BETTER IN MATHEMATICS IF YOU USED A POCKET CALCULATOR?

(a) Yes (b) No

27. DO YOU THINK POCKET CALCULATORS EVER MAKE A MISTAKE?

(a) Yes (b) No

28. DO YOU THINK IT IS A GOOD IDEA FOR PEOPLE TO USE A POCKET CALCULATOR?

(a) Yes (b) No

WHY? _____

_____

THANK YOU FOR YOUR CO-OPERATION